eye, their retinal images must be separated by at least one unexcited retinal cone. The distance between the two images must therefore be ·004 mm., or the intervening cone may be encroached upon. Therefore the minimum visual angle

$$\theta = 2a = 53{\cdot}236''.$$

Now Jupiter's edge and his first satellite may subtend at the sun an angle of 1·33″, so that we may regard this as the average angle subtended at the earth. Hence we see that there is no optical reason why the four satellites should not be seen by the naked eye. If they were sufficiently bright they no doubt could be distinguished by the normal Englishman's eye. "It must be remembered, however," as Sir Michael Foster says, "that the fusion or distinction of sensations is ultimately determined by the brain. The retinal area must be carefully distinguished from the sensational unit, for the sensation is a process whose arena stretches from the retina to certain parts of the brain, and the circumscription of the sensational unit, though it must begin as a retinal area, must also be continued as a cerebral area, the latter corresponding to, and being, as it were, the projection of the former." No amount of education can make the sensational unit smaller than the minimum retinal area, though by practice the cerebral area may be made more sensitive to minute sensational impulses.

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ELECTRIC TRACTION TROUBLES.

THE English—the pioneers in the development of railways, steamships, the telegraph, and other inventions of the nineteenth century—are now running the risk of becoming a nation of imitators. Apart from the fact that the entire route, Shepherd's Bush to the Bank, was not sent bodily across the Atlantic to be tunnelled, the Central London Railway might almost as well have been constructed in Central America as in Central London.

For not merely did the steam-engines come from Milwaukee, the electric lifts from New York, the dynamos, locomotives, and other electric apparatus from Schenectady, but the curious practice of requiring a passenger to first purchase a ticket and then drop it immediately into a box, as well as the projection of information into each end of a car on quitting each station are Yankee notions, and one expects to hear that the "next station is Chippawa" or Winettea, and not commonplace Bond Street or Oxford Circus.

The characteristics of American traction are convenience, comfort, speed, low fares and a liberal scattering of the electric current over the district generally. Chinese like, we have faithfully adopted them all. To go from the City to the Albert Hall, up to this summer, one went, of course, from the Mansion House to the South Kensington railway stations. Now one saves time and money by being whisked electrically to Lancaster Gate and walking across Kensington Gardens. No wonder, then, on C.I.V. Monday 230,000 people used the Central London Railway, enough passengers, in fact, to fill every seat one and a quarter times in every train from early morn on Monday to the small hours of the following day.

No need to issue return tickets at reduced rates when every passenger who goes by this line can be relied upon to return by it. What matters it, then—may think the artisan, the clerk, the stockbroker, the investor, and even, perhaps, the engineers and directors of the Central London Railway itself—by what route the electric current returns? The electric current that starts from the Marble Arch, say, must, from the nature of things, go back there. Why, then, should advantages be offered it that are not thought necessary in the case of the general public to induce a return home inside the tube?

If one were a shareholder *only* of the Central London Railway, one might find it difficult to realise that any other interest was of any consequence. But, if a considerable portion of one's income happens to be derived from dividends on the shares in gas and water companies, one may prefer that these sources of income shall not be seriously interfered with. Hence, the clean white glazed brick walls, the brilliant arc lamps, the pleasant gliding lifts, the entire absence of those rolling clouds of smoky steam that greet a passenger as he descends into the Euston Road on a damp, cold November day, fail to cheer him on his swift modern progress under Oxford Street, should he make the following little elementary calculations:—Over 2000 electric horse-power which, at times, every day is already actually put into the Central London Railway at a single sub-station between Shepherd's Bush and the Bank means a current of over 3000 amperes; and this current, after passing through the electro-motors on the trains in the neighbourhood of that sub-station, has to come back there through the *uninsulated* rails on which the trains run. Suppose, in consequence of these rails being *un*insulated, 10 per cent. of this return current strays outside the iron tube and comes back by the iron gas and water pipes running parallel with the railway on the ground above it. This means about ¾lb. of iron removed from the gas and water pipes in an hour in the neighbourhood of a sub-station.

Such large currents, however, as 3000 amperes are at present probably only seldom reached, therefore, to avoid even an approach to exaggeration, let us assume that the average current which strays into the gas and water pipes on its way back to a sub-station is only, say, $\frac{1}{100}$th of the maximum value of the current leaving a sub-station each day. This seems a modest enough estimate. Then, since the line works some eighteen or more hours per day, this means about *a quarter of a ton of iron* removed per year from the gas and water pipes in the neighbourhood of *each* of the places at which the current is fed into the railway. Consequently, as there are several such places between Shepherd's Bush and the Bank, this would lead to more than *one ton of iron* being eaten out of the pipes each year.

Is this important? Well, as holders of gas and water companies shares we should say, very! But are the travelling facilities of the London public to be interfered with, is the development of electric traction to be hampered—just when our people are having their first taste of the immense advantages that accrue from propelling trains and tramcars by electricity—simply because several millions sterling happen to have been invested on pipes, retorts, gasometers, waterworks, &c., and because there are people so blind as to actually prefer the receipts of regular dividends to the slavish copy of American practice?

Luckily, no such terrible alternative need be flourished in the faces of our democratic governing bodies, who, while naturally anxious to defend the people from the supposed extortions of the gas and water companies, are no less anxious to shield from the incursions of the electric traction capitalist a large class of persons with small incomes who have placed their savings in what they rightly regarded as safe investments—viz., the shares of gas companies.

Another electric service has been inaugurated this year in which trains as large as, or larger than, those on the Central London Railway are driven electrically over a far more difficult route—viz., from Earl's Court to High Street, Kensington, among ordinary trains over points and crossings.

And yet, in spite of this greater difficulty, there is not merely an insulated conductor to take the electric current to the trains, as on the Central London Railway, but also an insulated conductor to bring it back by; and the rails on which the electric trains run between Earl's Court and High Street, Kensington, are used simply for

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what they were originally put there—viz., to carry the weight of the train, and not to ineffectually carry an electric current also. Such a system enormously diminishes the electrolytic corrosion of gas and water pipes; and, since it is a system that has been designed by a celebrated firm of consulting electrical engineers and carried out by a no less celebrated firm of electrical contractors, surely nobody suggests that it is in any sense impracticable.

It will be urged, however, that on that vast network of tramways lying between Uxbridge Road and Acton, Hammersmith and Hounslow, Kew and Richmond, &c., which will shortly be worked electrically, two overhead insulated conductors are impossible, and we must adopt the American system. Yes, but what American system? The conduit system, for example, employed already for years in Washington, and of which some seventy miles now exist in New York, in which there are no overhead wires at all, but an insulated going and an insulated return conductor, both under the street? Or is all this too modern for England, and can we not project ourselves in advance of where America was several years ago, and must we resort to the old insulated trolley wire to take the current and the *un*insulated rails to bring it back?

Why, only recently there was suggested, in one of the technical papers, a proposal to overcome all this difficulty in the case of street electric tramways by taking the current to the cars by means of an overhead trolley wire as hitherto, but using instead of the rails as the return conductor an *insulated* cable which was connected automatically with a car as it passed along and which, differing in potential from the earth by only a few volts, could not give rise to appreciable leakage to the ground. Will an insuperable barrier to a trial of such an English system be found in the fact that its parent, called "surface contact," was itself born of English parents in 1881? Must it, like an opera singer of forty years ago, first adopt an Italian name before it will be accepted by a British public?

Already the Central London Railway Co. has given notice of an application to Parliament for powers to extend westward and eastward; every week now some new underground electric railway scheme blossoms forth for London, while in a few years electric tramways will doubtless be a common method of conveyance in this city. An urgent question, therefore, that London must ask itself *to-day* is—Does it want to preserve its gas and water pipes?

AGRICULTURAL DEMONSTRATION AND EXPERIMENT.

THE issue by the Board of Agriculture of the "Annual Report on the Distribution of Grants for Agricultural Education and Research in the year 1899-1900," directs attention to a department of educational activity which was practically non-existent in the beginning of the present decade. From this it need not be inferred that there was no education in agriculture—both in the class-room and on the field—before this date. The work of Rothamsted, of our leading agricultural societies, and of certain agricultural colleges, is conclusive evidence to the contrary. But it was not till some ten years ago that the aid of the State was given to the establishment and maintenance of agricultural departments in provincial colleges, and of independent teaching institutions, which should be in a position to supply education and advice to the agricultural community in their district.

The report before us summarises the courses of instruction, attendance, intra- and extra-mural work, and financial aspects of each of the eleven English and Welsh collegiate departments and teaching institutions that divide amongst them 7750*l*. of the Board's grants. The grants to Scotland have, since 1896, been paid through the Scotch Education Office, so that the work of North Britain does not come within the purview of the Board's report.

Within certain limits, each institution is allowed to administer its grant and organise its work on the lines that experience has shown to be most consistent with local requirements. As a result, we find considerable variety in the educational ramifications of the different centres, though this variety is less pronounced now than formerly. Practically all the colleges receiving the Board's grants have arranged courses of instruction, extending over two or three years, which lead up to a certificate, diploma or degree. In addition to these extended courses, most of the colleges are now holding short courses of six to ten weeks, which are specially designed to meet the wants of young farmers who cannot be spared from home for a longer period. Such classes have proved most useful in America and on the Continent, and they are also being well attended in this country.

A prominent feature of the work of all the colleges is the conduct of field demonstrations and experiments, of which a condensed account is given in the second section of the appendix of the Report under notice. This form of educational work was vigorously prosecuted by Young and Marshall in the latter half of last century, and, in the face of a mild undercurrent of opposition, it has been continued ever since. It is a form of educational activity that has been largely developed in the United States, in Canada and on the Continent, so that it may fairly be urged that, whatever its weaknesses, it has, on the whole, gained extensive adoption by reason of intrinsic merit. The objectors to this form of education, or means of agricultural improvement, base their opposition on the following grounds:—

(1) The difficulty of getting a series of plots on soil of equal quality.

(2) The danger of applying results obtained on one farm to the agricultural practice of another.

(3) The possible interference with results of extraneous causes, *e.g.*, birds, mammals, insects, diseases, weather.

(4) The misinterpretation of the value of purely quantitative results.

No doubt the usefulness of field trials may be marred, or worse, by failure under these heads, but the exercise of ordinary care in selecting the land, the rejection of results that have manifestly been unduly influenced by extraneous causes, and, above all, the frequent repetition, both as regards place and season, of the experiments, must in the end furnish a set of figures that cannot fail to prove a useful guide in agricultural practice. If one may not indulge in wide generalisation from even a considerable number of concrete cases, that is no valid argument against field trials. On the contrary, it is fair to say that if there are a large number of soils that require special treatment, it is the more necessary that farmers should be made familiar with the arrangements and method of field trials, in order that they may, by their aid, inquire into the manurial and other requirements of their own land. In point of fact it is probable that therein lies the main value of such work. No one, who has given careful heed to the experimental results of past years, will deny that, at least under certain conditions of soil, some very striking and unexpected results have been obtained. Farmers who see such results, recognise that they have made the acquaintance of facts that they would not have anticipated, and they naturally conclude, and rightly, that if the unexpected has

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